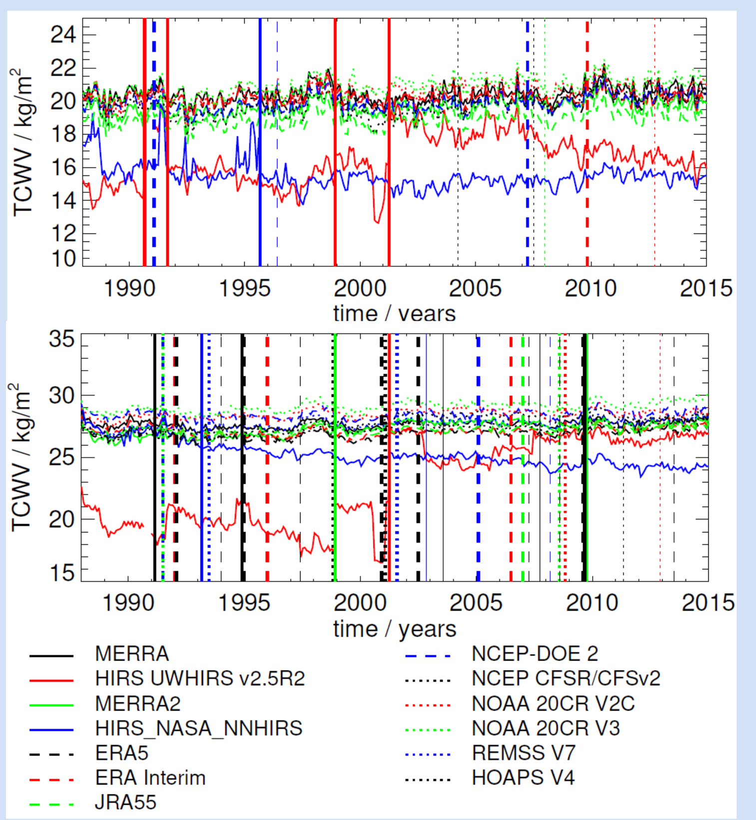
The GEWEX water vapor assessment (G-VAP)

Marc Schröder[1], Tim Trent[2], Shu-peng Ho[3] and the G-VAP community

[1]Deutscher Wetterdienst, Offenbach, Germany, [2]U. Leicester, NCEO, Leicester, UK, [3]NOAA, College Park, USA

The GEWEX water vapor assessment (G-VAP) was initiated by the GEWEX Data and Analysis Panel (GDAP). The major purpose of G-VAP is to quantify the state of the art in water vapour products being constructed for climate applications, and by this support the selection process of suitable water vapour products by GDAP (see gewex-vap.org). The assessment provides an overview of available data records (see gewex-vap.org→Data Records) and results based on consistent product inter-comparisons and comparisons to other observations. Results from the first G-VAP phase are published in, e.g., Schröder et al., 2018 (ESSD) and 2019 (Rem Sens). Subsequently the G-VAP data archive was updated by considering new versions and new records. The analysis was adapted and enhanced, a.o., by a dedicated land and variability analysis. The results presented here consider the new, full archive (inter-comparison, period 2003-2014) and long-term TCWV data records (all else, period 1979/1988-2014). Results from the first phase are largely confirmed and refined and new results are summarized below (more details in Trent et al., 2024).

Homogeneity and coincidence of breaks with changes in observing system



Data record	Date PMF	Breaksize PMF	Breaksize SNH	Event
global land				
ERA-Interim	2009-10	**-0.23**	**-0.18**	Approximate start of assimilation of AMSR-E and F16 data, see [1]
HIRS UWisconsin	1990-08	**3.86**	**3.42**	HIRS/2 on NOAA-10 became very noisy. Early HIRS/2 data is an outlier because of the missing split window (12 μm) band.
	1991-08	**-1.74**	**-2.03**	NOAA12 is operational since 1991-09.
	1998-11	**1.63**	**1.65**	NOAA15 is operational since 1998-12.
	2001-03	**3.48**	**4.82**	NOAA16 operational since 2001-03.
NCEP CFSR/CFSv2	2004-03	**0.52**	**0.41**	Approximate start of assimilation of data from AIRS and AMSU-A onboard MODIS-Aqua [7].
	2007-06	**0.47**	**0.40**	Approximate start of assimilation of data from Metop-A [7].
NCEP-DOE 2	1991-01	**-0.2**	**-0.14**	Unclear
	1996-05	0.16		Approximate date of new snow climatology.
	2007-03	**0.30**	**0.25**	Unclear
NNHIRS	1995-08	-1.15		The break does not seem to coincide with a change in NOAA satellites. It marks the end of a period of approximately two years with a series of anomalies.
NOAA 20CR V2C	2012-09	-0.60		Unclear
NOAA 20CR V3	2007-12	-0.43		Unclear

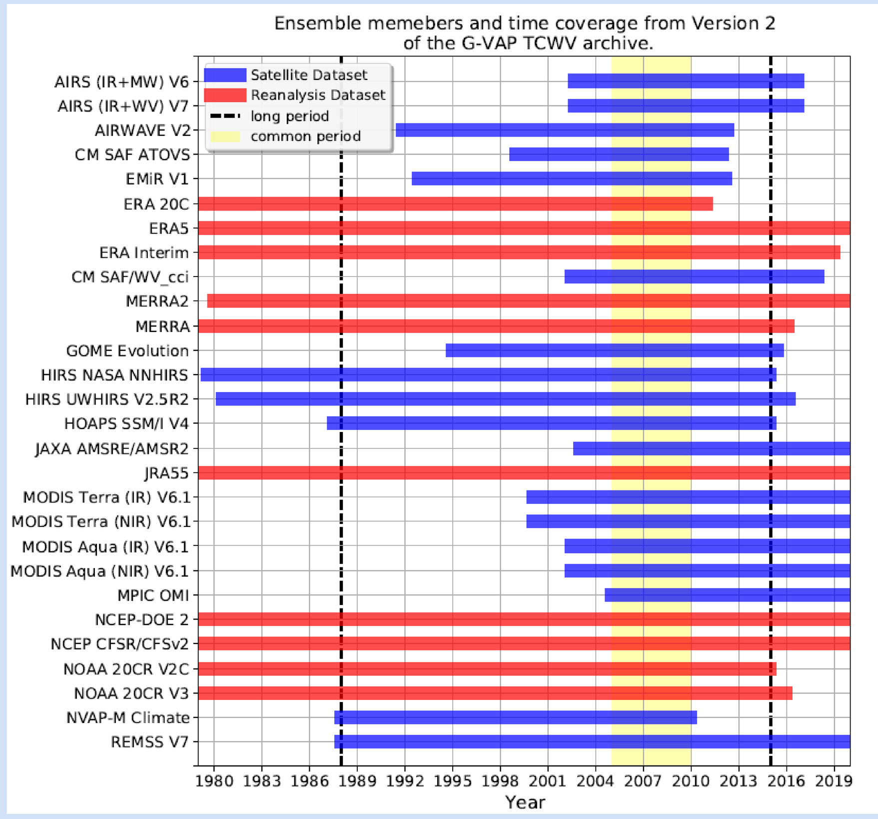
references: [1] Dee et al. (2011); [2] Hersbach et al. (2020); [3] Kobayashi et al. (2015); [4] Rienecker et al. (2011); [5] McCarty et al. (2016); [6] Gelaro et al. (2017); [7] Saha et al. (2010); [8] Schröder et al. (2016); [9] Slivinski et al. (2019)

▲ Table 1: Date and strength of break points and coincident changes in the observing system. Data: TCWV over land, with ERA5 as reference. Break point size is printed in bold if PMF test and SNH test results agree on detection time. Considering results over land and ocean 20% of the breakpoints do not coincide with a change in the observing system.

▲ Figure 2: Anomaly time series of TCWV averaged globally within 60°N/S: land (top) and ocean (bottom). Time series were shifted by climatological averages. Vertical bars show break points. Bars are printed in bold when PMF test (Wang, 208a,b) and SNH test (Hawkins, 1977, Alexandersson, 1986) agree on detection time.

Figure and table adapted from Trent et al. (2024).

Data archive

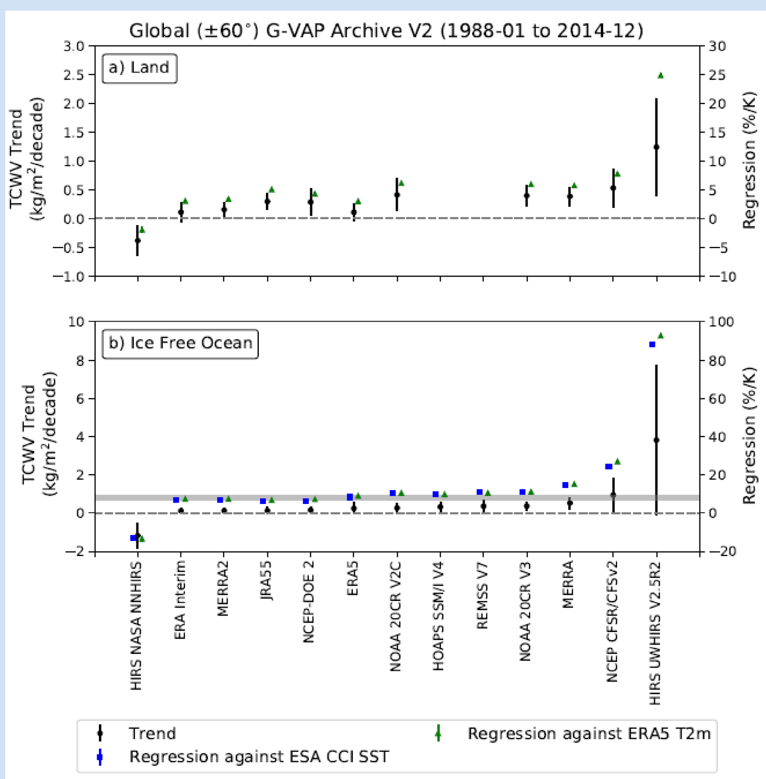


► Figure 1: Coverage of TCWV records included in version 2 of the G-VAP data archive from 1979 to December 2019. Satellite records are shown in blue, whilst reanalysis is indicated in red. The two analysis periods, "long" (1988-01-01 to 2014-12-31) and "short" (2005-01-01 to 2009-12-31), are represented by black dashed lines and yellow shaded areas, respectively.

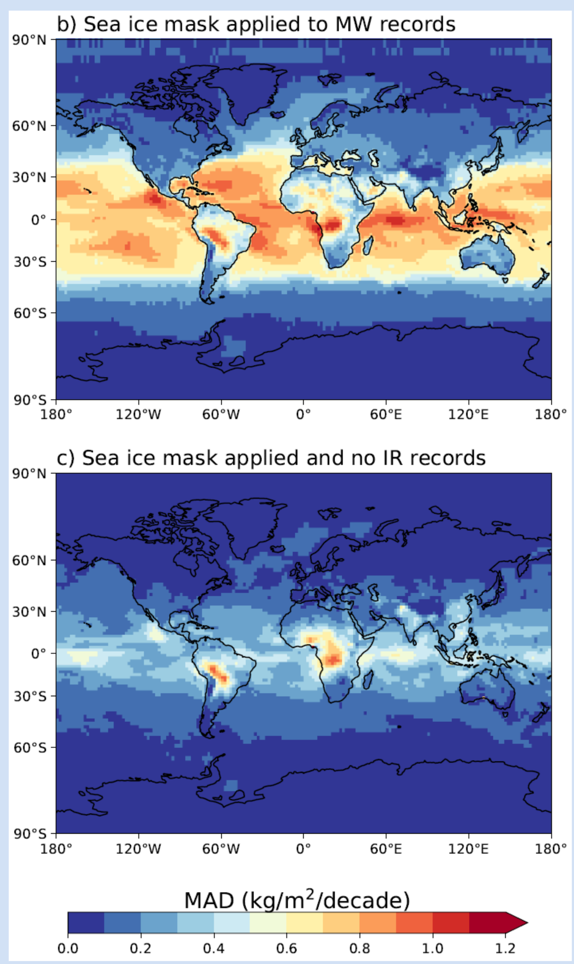
From Trent et al. (2024).

- Regridded to common grid (2°x2°, regular longitude / latitude),
- G-VAP data archive v1.0:
  - common vertical levels: 1000, 700, 500, and 300 hPa
  - common period depending on parameter,
  - freely available via doi-reference (10.5676/EUM_SAF_CM/GVAP/V001).
- G-VAP data archive v2.0: release planned in 2024/2025.
  - TCWV only, details given in figure 1.

Trend estimation and regression



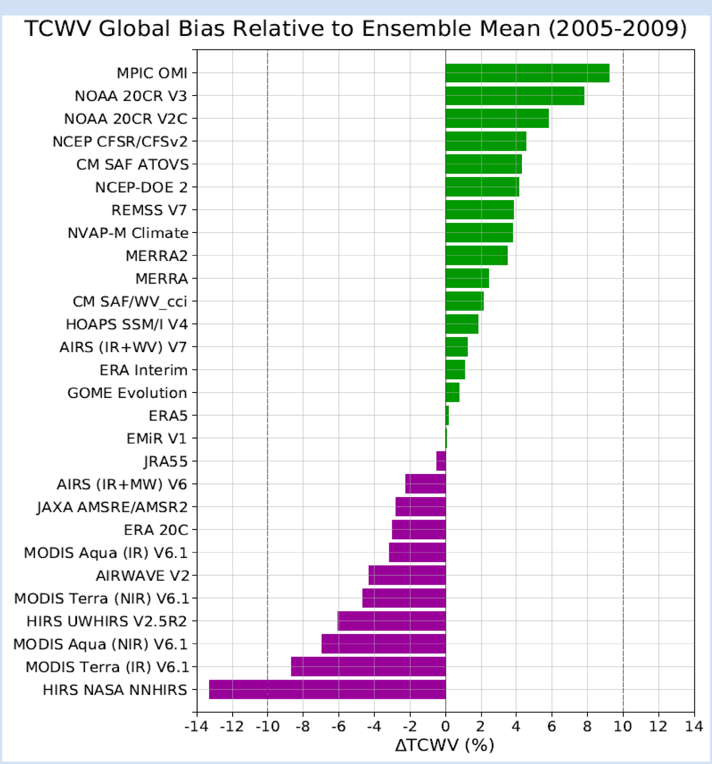
▲ Figure 3: Trend estimates over ocean (bottom) and land (top, <60°N/S), sorted in ascending order and results from regression analysis (Dessler and Davis, 2010, Mears et al., 2007), with 1-sigma uncertainty. Black grey bar mark general theoretical expectation range.



► Figure 4: Mean absolute difference in trend estimates (after Weatherhead et al., 1998, Mieruch et al., 2014) for TCWV: top – all 14 long-term data records; bottom – HIRS based records removed

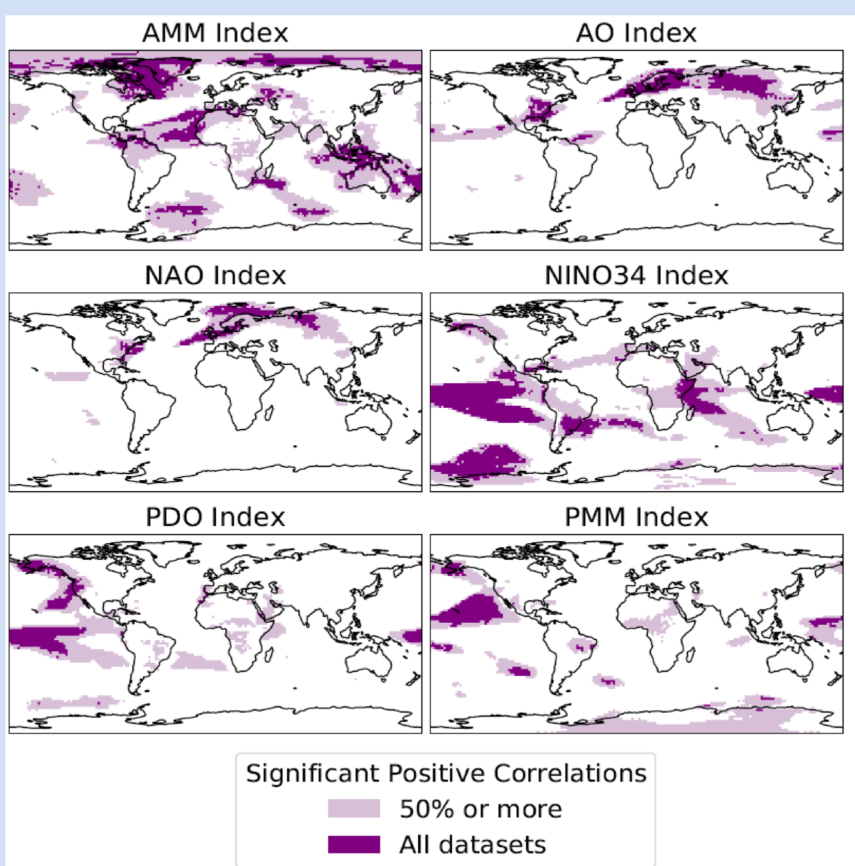
Both figures from Trent et al. (2024).

Inter-comparison



▲ Figure 5: Global TCWV differences of each archive member to the ensemble mean for the period 2005-2009. Average global differences have been summed and then normalised by the ensemble mean. For records that have missing data, the ensemble mean is recalculated by excluding these areas (Trent et al., 2024).

Variability analysis



▲ Figure 7: Spatial maps where the records that cover the long period (1988-2014) significantly correlate with the different climate indices (here positive only is shown). From Trent et al. (2024).

Conclusions

G-VAP provides a decent overview of available water vapour data records at http://*gewex-vap.org*. The G-VAP data archive v1.0 has been updated using new versions and products, now covering the period 1979-2019, with gaps filled with undefineds. Overall results confirm previous results in G-VAP, though with differences in the details. New results include the following: The effort has been extended with an analysis of standard deviation, dedicated land area analysis and analysis of variability. Associated results emphasise the large variability between the data records over the poles, South East Asia and dry atmospheres in general. The ENSO contribution to the TCWV variability is largely consistent in terms of spatial patterns between the data records. However, it exhibits considerable variability in strength. As in phase 1 the majority of data records are affected by break points and most of the break points can be attributed to changes in the observing system. The break points are largely different over land and ocean. Also, the trend estimates are typically significantly different and are usually not in line with theoretical expectation.

More results are available in Crewell et al. (2021) and in the special issue (https://acp.copernicus.org/articles/special_issue1118.html)

The next G-VAP workshop likely takes place at DMI, Copenhagen, Denmark in 2025.

Recommendations (subset):

- Space Agencies, PIs, G-VAP: Enhance quality analysis of profile data records over open ocean, in particular over high pressure areas/subsidence areas and stratus.
- GEWEX, Space agencies, G-VAP: It is needed to assess options to merge the various observing systems to provide long-term, high resolution water vapour profile data.
- Space Agencies: Need for inter-calibrated radiance/brightness temperature data records and homogeneously reprocessed (instantaneous) satellite data records.
- New - CGMS, Space agencies: Carefully improve the temporal stability of HIRS TCWV data records. HIRS offers the unique opportunity to retrieve TCWV over land and ocean beginning in the late 1970s .

References

Alexandersson (1986, JClim), Crewell et al. (2022, AMT), Dessler+Davis (2010, JGR), Hawkins (1977, JASA), Mears et al. (2007, GRL), Mieruch et al. (2014, JGR), Schröder et al. (2018, ESSD, 2019, Rem Sens), Trent et al., (2024), accepted by ACP, Wang (2008a,b, JAOT, JAMC), Weatherhead et al. (1998, JGR)

@Climate_SAF

https://twitter.com/climate_saf

Satellite-Based Climate Monitoring

gewex-vap.org www.cmsaf.eu - marc.schroeder@dwd.de

June 2024